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ABSTRACT

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Difficulty in Concept Identification as a Function of Stimulus Saliency and Concept Complexity

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Abstract

The relationship between conceptual complexity and stimulus saliency was explored in a 3 x 4 factorial design using 144 undergraduates. Levels of complexity were represented by varying the ratio of relevant-to-irrelevant dimensions (1:3, 2:2, and 3:1). The saliency factor varied according to the discriminability between each attribute within relevant and irrelevant dimensions. Concept stimuli consisted of four building elements, each containing five attributes that varied in size. The curvilinear relationship found among the complexity conditions for trials and errors cancelled out the differences in difficulty between the four levels of saliency except where there was an equal proportion of relevant and irrelevant dimensions.

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Experimental research efforts that have been concerned with the perceptual saliency of attributes, e.g. various color hues, have been directed toward discovery of the ways in which variations in experimental materials and procedures affect ease of concept acquisition. Archer (1962) has found that varying the "obviousness" of stimuli affects the difficulty of a concept. Obviousness was varied according to the degree of similarity in the height of geometric figures. He reported that when three values of height were close together and at the same time served as a relevant cue for the concept, concept acquisition was more difficult. Likewise, concept difficulty increased when the irrelevant information was "obvious" or when the difference between the irrelevant stimuli was maximized However, as Sechrest and Kaas (1965) noted, "there was not a positive indication that the values chosen as highly similar were actually clearly discriminable by the subjects in Archer's experiment (p. 327)."

It is clear that concept difficulty may be affected by a lack of perceptual discriminability among the stimuli within a dimension. Accordingly, there is a need to establish unambiguously the subject's ability to discriminate levels within less salient dimensions if Archer's (1962) notion is to be objectively tested. The major question is how does salience of concept problem information, which may be defined as the degree of obviousness (similarity) of relevant and irrelevant information (Archer, 1962) or as the discriminability among the values (within a dimension) that are relevant or irrelevant (Sechrest and Kaas, 1965), contribute to efficient performance in concept identification problems? Furthermore, the ratio of relevant to irrelevant dimensions present within a single concept identification task may also have an effect on the complexity of the concept and on performance (Peterson, 1962). More specifically, how is performance affected when a concept problem includes either one relevant and three irrelevant dimensions (1R-3I), two relevant and two irrelevant dimensions (2R-2I), or three relevant and one irrelevant dimensions (3R-1I)? Several studies have attempted

to investigate which of the two kinds of information (relevant and irrelevant) produces relatively greater amounts of concept complexity (Archer, 1954; Bulgarella and Archer, 1962; Peterson, 1962; Walker and Bourne, 1961). Peterson (1962) indicated that as the percentage of relevant cues increased, performance improved. However, the high percentage (3R-1I) relevant group failed to correctly identify all the relevant attributes in the task and as such, had the lowest percentage of correctly identified relevant attributes. Bulgarella and Archer (1962) indicated a disproportionate increase in difficulty when the number of relevant dimensions were increased; whereas Walker and Bourne (1961) reported a linear increase in difficulty as a function of increasing the number of relevant attributes. These trend differences may be attributable to the differential use of response categories.

The purpose of the present investigation was to determine to what degree concept acquisition is affected by the saliency of those dimensions present within a conceptual task. As such, what will happen to performance in a concept learning task when the relevant dimensions are either salient or not salient and/or when the irrelevant dimensions are either salient or not salient? Saliency was defined as the discriminability of attributes within a particular dimension. In other words, the attributes within a dimension that appear to be less discriminable (or appear to be very similar in value but discriminable) constitute the nonsalient and hard to discriminate dimension, while those attributes that are highly discriminable and easy to discriminate (or appear to be distinctly different) constitute the salient and easy to discriminate dimension. Thus it was hypothesized that concepts will be most difficult and least efficient to solve when the dimensions, both relevant and irrelevant, have the following discriminability characteristics (range is from most difficult and least efficient respectively): 1) hard to discriminate relevant and irrelevant attributes (HR-HI); 2) hard to discriminate relevant and easy to discriminate irrelevant attributes (HR-EI); 3) easy to discriminate relevant and hard to discriminate irrelevant attributes (ER-HI); and 4) easy

to discriminate relevant and irrelevant attributes (ER-EI). Furthermore, the ratio of relevant to irrelevant dimensions present within a single concept identification task may also have an effect on performance. That is, how is performance affected when the problem includes either one relevant and three irrelevant dimensions, two relevant and two irrelevant dimensions, or three relevant and one irrelevant dimensions? The present investigation held the total number of dimensions constant while utilizing three complexity conditions. Thus it was hypothesized that concept problems containing one relevant and three irrelevant dimensions (1R-3I) would be least difficult and most efficient, problems containing two relevant and two irrelevant dimensions (2R-2I) will be intermediate in difficulty and efficiency, and problems containing three relevant and one irrelevant dimensions (3R-1I) will be most difficult and least efficient.

An added factor utilized in the present investigation was the inclusion of concrete object representations of concepts. The use of concrete as opposed to abstract concepts has been discussed in the literature; however, it has rarely appeared in conjunction with saliency of those dimensions present in a concept attainment task .

Investigations in learning have as an ultimate objective, design of a more efficient learning environment. Better learning environments are governed by increased information about efficient methods for arranging learning materials. The question is, how do we arrange the learning environment to facilitate transfer and reduce interference in concept acquisition?

The present investigation should afford additional contributions to more efficient school learning of concepts based on the need to make certain kinds of information more salient or obvious to the student.

METHOD

Design

The design is a 3 x 4 factorial format representing three levels of complexity: one relevant--three irrelevant dimensions (1R-3I); two relevant—two irrelevant dimensions (2R-2I); 3 relevant--1 irrelevant dimensions (3R-1I) and four levels of stimulus saliency; hard relevant--hard irrelevant (HR-HI); hard relevant--easy irrelevant (HR-EI); easy relevant--hard irrelevant (ER-HI); easy relevant--easy irrelevant (ER-EI). The 12 treatment groups were exposed to one of 12 treatment conditions. For example, the first treatment group received condition 1HR-3EI (1 hard relevant dimension--3 easy irrelevant dimensions). The other eleven conditions are as follows: 2HR-2EI, 3HR-1EI, 1ER-3HI, 2ER-2HI, 3ER-1HI, 1HR-3HI, 2HR-2HI, 3HR-1HI, 1ER-3EI, 2ER-2EI, and 3ER-1EI. The number of dimensions remained constant at four for each concept problem.

In the concept problems, the subject was required to discover which relevant attribute/s is/are needed to finish building a nonsense machine (given the name Trapperdike). The design of a nonsense machine attempts to make the structure unfamiliar to the subject.

Apparatus

The stimuli were presented to the subject through a box-like structure (35 cm. wide x 39 cm. long x 23 cm. high) which had an opening (26 cm. x 11 cm.) in the front from which the stimuli were presented. The back of the box was open to allow the experimenter to rearrange the stimuli for the next trial. The four stimuli that appeared in each trial were presented through the opening in the front of the box on a sliding drawer. The stimuli for each trial were equally spaced in a horizontal array at the front of the sliding drawer. After a trial was completed the experimenter pulled the drawer back through the enclosed box so that the next trial could be arranged.

Procedure

The subjects were seated opposite each other at a table. The stimuli, when presented by the experimenter who sat at the head of the table, could be observed from either side of the apparatus drawer. A response sheet was made available to each subject, and they were responsible for indicating their responses in the proper spaces. The subjects were then instructed to try to name the objects that appeared on the apparatus drawer (Eyescrew, Bolt, Nut, and Washer). If the subjects were unable to give the proper label for each object, the experimenter volunteered the correct name and continued until they could name all four without help. The ability to label the objects was indicated on the response sheet by noting the objects not identified initially.

To determine if the three levels within each of the salient (easy to discriminate) and nonsalient (hard to discriminate) dimensions were discriminable, the subjects were shown three objects varying in size according to the characteristics of the dimension (either salient or nonsalient) used for that particular condition. The set of three objects (e.g., three Eyescrews) from each dimension (Eyescrew, Bolt, Nut, and Washer) was shown separately to the subjects one at a time.

The experimenter instructed as follows:

> I am going to show you 3 objects, one at a time. After I show you each object you are to tell me which one was the largest, the first, second, or third one, which one was the smallest (first, second, or third) and which one was the medium sized one (first, second, or third). I will show you the first object for five seconds, then I will replace it with the second object, then the third. Remember, after I show you all 3 objects you are to tell me which one is the largest sized, smallest sized, and medium sized object.

The procedure was continued for each of the 4 dimensions (Eyescrews, Bolts, Nuts, and Washers). Each of the different sized objects were presented in random order. If the subjects were unable to discriminate the difference in size, the discrimination procedure was repeated until all subjects were able to discriminate the size difference.

As soon as discriminability had been established subjects were shown the picture of the nonsense machine called a Trapperdike. At this point the subjects were given a sample problem and were instructed as follows:

> Now lets go on to a sample task to familiarize you with the procedure used in the problem task. The problem is a hypothetical one. This is a Trapperdike (show subjects the illustration). To build this hypothetical nonsense machine you may need some different sized Eyescrews, Bolts, Nuts, and Washers (show materials). Everyone look over here (experimenter lifts box up to reveal objects) and you will see the various sized objects that we will be using. The problem is, which of the different sized objects from the ones that I just showed you will you need to complete the Trapperdike. For example, I'm going to show 4 different sized objects, each of which will be chosen from the group of different sized Eyescrews, Bolts, Nuts, and Washers that I just showed you.
>
> I know that these two (one or three) objects (points to one, two, or three different objects in the row, depending on the experimental treatment; e.g., in the 1HR-2EI condition the experimenter would point to only one object such as the Bolt) are needed to complete the Trapperdike. Everytime these two (one or three) particular sized objects appear within the row of four objects you are to circle "yes" on your answer sheet where it says Sample Problem, meaning that the two (one or three) important objects are present. So, if for example I asked you if the two (one or three) important objects were present among the four in front of you now would you circle "yes" or "no" (subject responds)? If you circled "yes" you were right, or if you circled "no" you were wrong. Everytime you respond I will tell you the right answer. In this case you were right if you circled "yes" because the two (one or three) objects needed are among the four in front of you. Now I am going to rearrange a new row of objects, but remember, if the two that are important appear among the next four objects then you are to circle "yes" if the two (one or three) objects are not there then you circle "no".

The experimenter continued the above procedure until the subjects had received 2 positive and 2 negative instances as sample trials. The sample problem contained the same four dimensions used in the main problem however, different relevant-irrelevant and salient-nonsalient dimensions were chosen. The subjects were then instructed to go to the experimental problem on their response sheet.

> Lets go on to the main problem. This time I am going to choose from the same different sized Eyescrews, Bolts, Nuts and Washers, two (one or three) different objects that you might need to finish building the Trapperdike. But this time I'm not going to tell you what different sized objects I have in mind. It is your task to figure out what two (one or three) different sized objects I have in mind that you would need to finish building the Trapperdike. When you have gotten 10 answers in a row correct you have finished.

In addition to recording the number of trials and errors to criterion (10 consecutive correct responses), time for the experimental trials was recorded via a stop watch. The experimental concept problem lasted 72 trials or until the tenth successive correct response was given by the subject, whichever occurred first.

Subjects

The subjects were 144 undergraduates (70 males and 74 females) enrolled in the introductory psychology course at West Virginia University. Subjects were randomly assigned to each condition. Each task was administered to groups of 2 to 4 subjects. The subjects were assigned upon appearance at the testing room, to treatment groups in rotation, with one replication of the twelve condition orders before each succeeding replication.

Stimulus Materials

The stimuli chosen to represent the four stimulus dimensions were Eyescrews, Bolts, Nuts, and Washers. The 3 levels for each dimension were varied according to size. The salient or easy to discriminate

dimensions varied in size as follows: Eyescrews--3/8, 5/8, and 7/8 inch inside diameter of eye, Bolts--1/4, 1/2, and 3/4 inch outside diameter, Nuts--1/4, 1/2, and 3/4 inch inside diameter, and Washer--1/4, 1/2, and 3/4 inch inside diameter. The nonsalient, or hard to discriminate dimensions were also varied according to size; however, the difference in size between each level within a dimension was of a lesser degree. The nonsalient attributes were as follows: Eyescrews--1/2, 5/8, and 3/4 inch inside diameter of eye, Bolts--3/8, 1/2, and 5/8 inch outside diameter, Nuts--3/8, 1/2, and 5/8 inch inside diameter; and Washer--3/8, 1/2, and 5/8 inch inside diameter.

In addition, the items varied in other dimensions as well, depending on the characteristics of the stimuli. For example, the different sized Eyescrews varied in size according to the diameter of the eye and the length of the screw. The size of the Nuts varied according to the inside diameter and the height of the nut. However, the experimental intra-level difference between each level within the more salient or easy to discriminate dimensions was considered to be 1/4 inch. In other words, the difference in size was 1/4 inch between each level in the more salient dimensions. The nonsalient or hard to discriminate dimensions varied in size by only 1/8 of an inch.

The key to the difference between the two types of dimensions (salient or nonsalient) lies in the perceptual salience of the critical attributes for each of them. Based on Archer's (1962) findings, concepts tend to be more difficult when the critical attribute is a nonobvious property of the stimulus. As the distance on the continuum between values increases, the salience or obviousness of the particular dimension may very well be heightened and attended to (Sechrest & Kaas, 1965).

In presenting the stimuli, for example, condition 1HR-3EI would require that one of the hard to discriminate or nonsalient dimensions be chosen as the relevant dimension in combination with three of the

easy to discriminate or salient dimensions. In other words, the 3 Washers (hard relevant dimension) varying in size by 1/8 inch among the levels would be presented in combination with other attributes of the remaining three dimensions (Eyescrews, Bolts, and Nuts). Each of the attributes within the three irrelevant dimensions would vary in size by 1/4 inch among dimension levels. Systematic combination of four dimensions with three levels of each were determined. Nine instances randomly selected from all the possible combinations were used. The nine instances were randomly distributed eight times in each task, setting the total number of possible instances appearing in any one task at 72.

RESULTS

The number of trials, errors, and time to criterion were recorded for each condition. The means and standard deviations are presented in Table 1. These data were analyzed using an overall analysis of variance to examine the three levels of complexity (1R-3I, 2R-2I, and 3R-1I) and four levels of saliency (HR-HI, HR-EI, ER-HI, and ER-EI) separately as main effects. The relationship of their possible interaction was also examined by crossing the three levels of complexity with the four levels of saliency.

Insert Table 1 about here

Conceptual Complexity

The concept complexity main effect contained three levels of complexity. The low complexity condition contained 1 relevent--3 irrelevant dimensions (1R-3I), the medium complexity condition contained 2 relevant--2 irrelevant dimensions (2R-2I), and the high complexity condition contained 3 relevant--1 irrelevant dimensions (3R-1I). The overall analysis of variance for the main effects of complexity showed that the three complexity levels differed in difficulty on trials (F=10.618, df=2/132, $p < .01$), errors (F=9.039, df=2/132, $p < .05$).

Insert Table 2 about here

The Newman-Keuls multiple comparison technique was used with the overall analysis to determine the sequence of difficulty for the three complexity levels. No significant difference was found between the low complexity condition (1R-3I) and the high complexity condition (3R-1I) for trials, errors, and time to criterion ($p > .05$). However, the medium complexity condition (2R-2I) was significantly greater in difficulty when compared with both the low 1R-3I complexity condition ($p < .01$) and the high 3R-1I complexity condition ($p < .01$) for trials, errors, and time to criterion.

Saliency

The four levels of stimulus saliency constituted four combinations of relevant and irrelevent--hard and easy dimensions ranging in respect to difficulty (beginning with the most difficult): 1) hard relevent -- hard irrelevant (HR-HI), 2) hard relevant--easy irrelevant (HR-EI), 3) easy relevant--hard irrelevant (ER-HI), and 4) easy relevant--easy irrelevant (ER-EI). The overall analyses of variance for the main effects of saliency showed that the four levels (HR-HI, HR-EI, ER-HI, and ER-EI) differed in difficulty on trials ($F=4.40$, $df=3/132$, $p < .01$), errors ($F=4.628$, $df=3/132$, $p < .01$), and time to criterion ($F=7.152$, $df=3/132$, $p < .01$). See Table 2 for overall analyses.

In order to determine how the four levels of saliency differed the Newman-Keuls multiple comparison technique was used. No differences were found among the means for 5 of the 6 comparisons for trials ($p > .05$); however, one comparison did indicate a significant difference between the most difficult HR-HI level and the least difficult ER-EI level ($p < .01$) in the direction of greater trials, errors, and time to criterion for the HR-HI condition. Further examination of the means for errors and time to criterion also

Mean scores for these conditions are depicted in Figure 1. The figure clearly shows that the four levels of saliency were of little importance when solving concept problems with 1 relevant-3 irrelevant dimensions (1R-3I) and 3 relevant--1 irrelevant dimensions (3R-1I). However, when the concept problem contained 2 relevant--2 irrelevant dimensions (2R-2I: most difficult complexity condition) concept difficulty increased in a nonlinear fashion as a function of the saliency of the stimuli used in both the relevant and irrelevant dimensions. It appears that there were greater trials, errors, and time to criterion for saliency conditions ranging in difficulty beginning with the HR-HI condition (most difficult), HR-EI condition, ER-HI condition, and ER-EI condition (least difficult) for the 2R-2I complexity condition.

Insert Figure 1 about here

Analysis of the three complexity conditions (1R-3I, 2R-2I, and 3R-1I) within each level of saliency (HR-HI, HR-EI, ER-HI, and ER-EI) was performed using the Newman-Keuls means comparison procedure for trials, errors, and time to criterion. No significant differences were found between the three complexity condition means within the ER-HI (moderately difficult) or the ER-EI (least difficult) saliency conditions for trials, errors, and time to criterion ($p > .05$). Within the most difficult HR-HI saliency condition the 2R-2I medium complexity condition was significantly greater in difficulty when compared with both the 1R-3I low complexity condition ($p < .01$, $p < .01$, and $p < .01$) and the 3R-1I high complexity condition ($p < .01$, $p < .01$, and $p < .01$) for trials, errors, and time to criterion respectively. Comparison of 2R-2I and 3R-1I complexity condition means yielded a significant differences for trials, errors, and time to criterion ($p < .01$, $p < .01$ and $p < .01$ respectively) for saliency condition ER-EI.

This same trend was apparent for saliency condition HR-EI where mean differences between complexity conditions 2R-2I and 1R-3I ($p < .05$) and between 2R-2I and 3R-1I ($p < .01$) were significantly different for time to criterion. Oddly enough, this same trend did not exist for trials and errors; however, complexity conditions 2R-2I and 3R-1I did differ significantly ($p < .01$ and $p < .01$ respectively) while the 2R-2I and 1R-3I conditions did not differ significantly ($p > .05$ for trials and errors).

Mean scores for these conditions are also depicted in Figure 1. It is apparent from the figure that the three levels of complexity did differ in difficulty when exposed to the most difficult HR-HI saliency condition. The mean differences indicated a trend toward more difficult concept solution in the 2R-2I complexity condition. Both the 1R-3I and 3R-1I complexity conditions indicated fewer trials, errors, and less time to criterion than the more difficult 2R-2I complexity condition. This same trend was present for time to criterion within saliency condition HR-EI; however, analyses on trials and errors indicate a difference between complexity condition 2R-2I and 3R-1I but no difference between the 2R-2I and 1R-3I conditions. In other words, when subjects were exposed to the HR-EI saliency condition, the 2R-2I complexity condition was more difficult than the 3R-1I complexity condition but did not differ in difficulty with the 1R-3R condition except when time to criterion was analyzed.

Object Label and Size Discrimination

An analysis of covariance was performed to determine whether the number of objects improperly labeled (Eyescrew, Bolt, Nut, and Washer) and the number of incorrect discriminations had contributed to the amount of variance due to treatment main effects (saliency and complexity) and the interaction (saliency x complexity) for trials, errors, and time to criterion. Analyses indicated that the covariates

(sum of incorrectly identified object labels and number of incorrect discriminations) did significantly contribute to the amount of variance; however, the differences among the adjusted means was negligible and the main effects of saliency and complexity and their interaction (saliency x complexity) did not change.

DISCUSSION

In general the findings show that when concepts are learned, if all the stimuli (attributes), both relevant and irrelevant are hard to discriminate, concept solution is difficult and inefficient. On the other hand, if all the stimuli (attributes) are easily discriminated, concept solution becomes easy and maximally efficient. It is also apparent that under conditions of mixed saliency where 50% of the attributes (either relevant or irrelevant) are hard to discriminate and 50% of the attributes (either relevant or irrelevant) are easy to discriminate concept solution is intermediate to the two extreme conditions.

The results of the interaction between saliency and complexity may give a possible explanation for the differences found among the four saliency conditions. No differences in trials, errors, and time to criterion were found among the four saliency condition means for complexity conditions 1R-3I and 3R-1I. That is, the discriminability of the stimuli (attributes) within each of the four dimensions were of little importance in concept problems where one of the dimensions was relevant and three were irrelevant (1R-3I) or when three of the dimensions were relevant and one was irrelevant (3R-1I). However, in problems that contained an equal proportion of relevant and irrelevant dimensions (2R-2I) differences in saliency produced dramatic effects, with best to poorest performance in HR-HI, HR-EI, ER-HI, and ER-EI respectively. This implies that the discriminability of stimuli

(attributes) within a dimension (relevant or irrelevant) will have the greatest effect on performance when there are equal proportions of relevant and irrelevant information (50% relevant - 50% irrelevant).

Concommittant to the equal proportion of relevant and irrelevant dimensions idea is the notion that the proportion of hard to discriminate stimuli (attributes) to easy to discriminate stimuli (attributes) may also effect performance. That is, 1) in a concept task that contains an equal proportion of relevant and irrelevant dimensions (e.g., 2R-2I) when 100% of the stimuli are hard to discriminate (2HR-2HI) concept solution is most difficult. 2) When there are equal proportions of hard and easy to discriminate stimuli (50% H - 50% E), whether they are relevant or irrelevant (2HR-2EI or 2ER-2HI), concept solution is moderately difficult. 3) when 100% of the stimuli are easy to discriminate (2ER-2EI), concept solution is least difficult This trend does not appear when there are unequal proportions of relevant and irrelevant dimensions (1R-3I and 3R-1I). This implies that the unequal proportion of relevant and irrelevant dimensions may cancel out the effects due to discriminability.

The results indicated a curvilinear relationship between concept complexity and performance. The trend in complexity indicates that the low complexity condition (1R-3I) was, as expected, less difficult than the medium complexity condition (2R-2I). But the medium complexity condition was unexpectedly more difficult than the high complexity condition. Comparison of the low complexity condition (1R-3I) and the high complexity condition (3R-1I) showed no difference in difficulty. Other investigations have found similar results between problem complexity and performance (Glanzer, Huttenlocker, and Clark, 1963; Laughlin, 1966, 1968, 1971). All held the total number of attributes constant while increasing the number of relevant attributes so that the number of irrelevant attributes necessarily decreased proportionally. In contrast, all the studies which have reported a linear relationship between performance and complexity have held the number of irrelevant

attributes constant while increasing relevant attributes (e.g., Bulgarella and Archer, 1962; Schvaneveldt, 1966; Walker and Bourne, 1961). Likewise other investigators have reported a linear relationship between performance and complexity due to added irrelevant information when the number of relevant attributes was held constant (e.g., Bourne, 1957; Bulgarella and Archer, 1962; Haygood and Stevenson, 1967).

From one viewpoint, therefore, the procedure used in the present study and previous studies reporting a curvilinear relationship (e.g., Glanzer, Huttenlocker, and Clark, 1963; Laughlin, 1966, 1968, 1971) have confounded the well established independent effects of either increasing relevant or irrelevant attributes (e.g., Bulgarella and Archer, 1962; Schvaneveldt, 1966; Walker and Bourne, 1961). However, from another viewpoint, the empirical determination of the relationship between performance and increasing problem complexity in a concept universe of fixed total complexity is a desirable undertaking. It is no less important than determination of the relationship in a concept universe proportionally increasing in total complexity. Much human thinking involves the establishment of progressively complex possibilities from a fixed conceptual universe. To illustrate, a chemist may attempt to synthesize a compound by varying increasingly complex combinations of elements from the fixed universe of known elements.

Thus the obtained curvilinear relationship between performance and increasing concept complexity in a fixed conceptual universe is interesting in itself. Further, subjects may be able to solve conceptual problems by determining irrelevant attributes as well as relevant attributes. The latter findings may have applicability to an important class of extra-experimental conceptual problems.

When it is possible for a learner to solve a problem by focusing on a single relevant dimension, solution appears to be no easier than when he/she can solve by focusing on a single irrelevant dimension.

When a learner is exposed to a problem that contains one relevant--three irrelevant dimensions or three relevant--one irrelevant dimensions, he/she may focus on the single dimension (whether relevant or irrelevant). The hypothesis may be that "this one is relevant" or that "this one is irrelevant" or simply, "this one is important". Thus, the single dimension (whether relevant or irrelevant) may provide all necessary cues for locating the important dimensions. Consequently, the learner obtains the knowledge that the remaining dimensions must all be relevant or irrelevant, depending on how the single dimension was characterized (either relevant or irrelevant). On the other hand, when a concept problem contains an equal proportion of relevant and irrelevant dimensions (e.g., two relevant--two irrelevant) greater memory load is created by the increase number of hypotheses that must be tested to isolate the relevant or irrelevant dimensions. Thus, a focusing strategy may reduce the number of possible hypotheses for a problem with a single relevant or a single irrelevant dimension.

The expected results that complexity increases as a function of an increase in the number of relevant dimensions (1R-3I, 2R-2I, and 3R-1I respectively) based on associative or mediational theory did not hold true for the present investigation. As such, the hypothesis testing notion provides a better explanation of these data than the associative-mediational model/s.

When teaching concepts that have many relevant characteristics, it may be important to also emphasize those characteristics that are irrelevant. In other words, it may be just as important to teach what a particular concept is as well as what it is not. Further work is required in analyzing and designing instruction of classroom relevant materials and procedures that provide easy discriminations.

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TABLE 1

MEAN TRIALS, ERRORS, AND TIME AND STANDARD DEVIATIONS FOR ALL CONDITIONS

Complexity	Dependent Variable	Saliency: HR-HI M	HR-HI SD	HR-EI M	HR-EI SD	ER-HI M	ER-HI SD	ER-EI M	ER-EI SD
	Trials	20.750	12.076	20.666	8.783	17.333	4.923	19.500	7.845
1R-3I	Errors	5.666	5.466	4.583	4.660	4.000	2.256	5.250	4.245
	Time	739.002	397.002	643.750	276.973	597.500	212.544	473.916	313.274
	Trials	43.583	24.526	30.166	19.696	24.333	10.174	18.500	6.112
2R-2I	Errors	14.500	10.405	9.166	7.432	5.916	3.232	3.333	1.874
	Time	1404.916	743.567	1041.250	680.214	739.583	340.564	540.000	192.141
	Trials	20.416	8.162	17.333	6.198	22.250	13.961	16.250	3.545
3R-1I	Errors	4.583	3.396	3.583	4.699	4.416	4.795	3.583	2.065
	Time	675.166	302.168	547.250	228.016	740.833	569.756	458.333	204.031

TABLE 2

OVERALL ANALYSES OF VARIANCE
FOR TRIALS, ERRORS, AND TIME

TRIALS

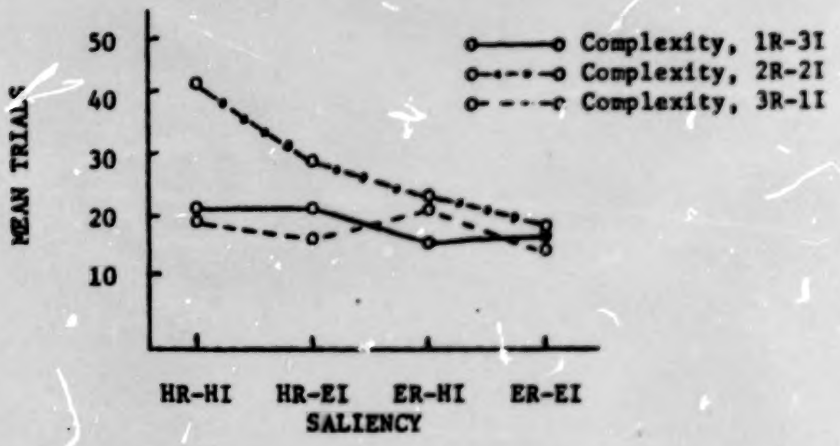
Source	SS	MS	df	F	p
A (Complexity)	3100.222	1550.111	2	10.618	< .01
B (Saliency)	1944.465	648.155	3	4.440	< .01
AB	2573.222	428.870	6	2.937	< .01
Residual	19268.916	145.976	132		

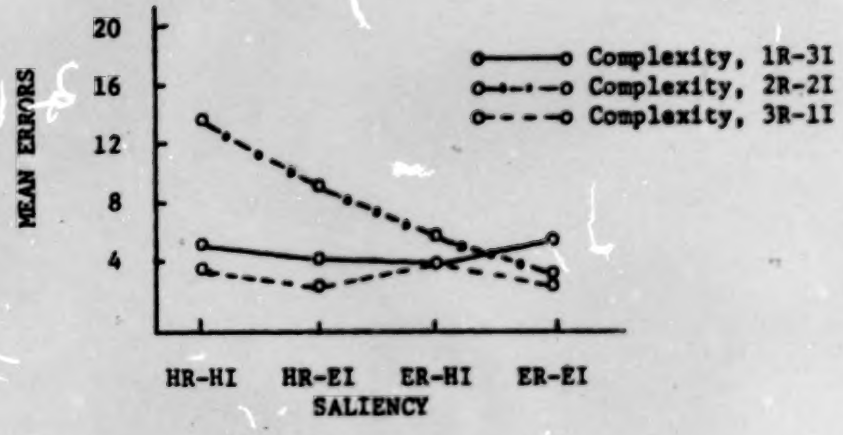
ERRORS

Source	SS	MS	df	F	p
A (Complexity)	471.680	235.840	2	9.039	< .01
B (Saliency)	362.243	120.747	3	4.628	< .01
AB	501.652	83.608	6	3.204	< .01
Residual	3443.750	26.089	132		

TIME

Source	SS	MS	df	F	p
A (Complexity)	3318836.5	1659418.27	2	9.686	< .01
B (Saliency)	3675912.3	1225304.10	3	7.152	< .01
AB	2454852.4	409142.07	6	2.388	< .05
Residual	22612458.5	171306.50	132		





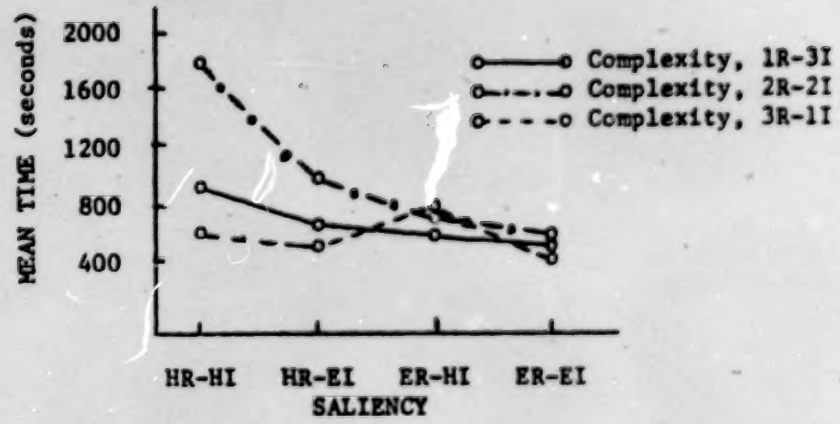


Figure 1. Saliency Across Complexity Means for Trials, Errors, and Time